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Science Response 2016/016

Gulf Region

UPDATED INDICES OF ABUNDANCE TO 2015 FOR STOCKS OF SIX GROUNDFISH SPECIES ASSESSED BY DFO GULF REGION

Context

DFO has conducted research vessel (RV) surveys in the southern Gulf of St. Lawrence, Northwest Atlantic Fisheries Organization (NAFO) Area 4T (Figure 1) using standardized protocols each September since 1971. In addition, two sentinel programs, a sentinel longline program beginning in 1995 and an August otter trawl survey beginning in 2003, have been conducted by DFO in collaboration with the fishing industry. Results of these surveys provide information on trends in abundance and biomass for groundfish species in the 4T area. While these data reflect trends in biomass and abundance and are a critical part of science-based stock assessments, a full assessment, including other sources of data, would be required to evaluate the impacts of management measures on population status. DFO Fisheries and Aquaculture Management (FAM) Gulf Region requested a review of the DFO survey information on the following species in NAFO Area 4T: Atlantic cod, American plaice, white hake, winter flounder, and yellowtail flounder. Information on witch flounder in the NAFO Div. 4RST area (northern and southern Gulf of St. Lawrence) was also requested. For this stock, data from RV and sentinel surveys of the southern Gulf were combined with data from similar surveys conducted in the northern Gulf to construct survey indices. A similar update of indices for these species was completed to the year 2014 (DFO 2015). The survey information in this update will be communicated by FAM to the various industry stakeholders for the intervening years of the multi-year management plan. The information may also be used to determine which stocks may benefit from a detailed review in future years.

This Science Response Report results from the Science Response Process of February 11, 2016, on the Update of Indicators for Groundfish Species of the southern Gulf of St. Lawrence (Atlantic Cod, White Hake, Witch Flounder, Winter Flounder).

Background

The six species and stocks covered by this report are under commercial fishery moratorium or have small annual Total Allowable Catches (TAC) (Table 1).

The September RV survey of the southern Gulf of St. Lawrence (sGSL) follows a stratified random sampling design (Figure 1), and includes sampling of fish and invertebrates using a bottom otter trawl. This survey, conducted annually since 1971, is the primary data source for monitoring trends in species distribution, abundance, and biological characteristics (e.g., size and age composition, growth) in the sGSL (for details see Savoie 2016). The same stratification scheme has been used since 1971, except for the addition of three inshore strata (401-403) in 1984. Unless otherwise stated, the analyses presented here are based on the 24 strata (415-438) sampled since 1971. Comparative fishing experiments were conducted to test for species-specific changes in fishing efficiency whenever there was a change in research vessel (1985, 1992, and 2004/2005) or trawl gear (1985). Furthermore there was a change from day only to

24-hr fishing in 1985, and both comparative fishing experiments and analyses of survey catches have been undertaken to estimate any species-specific changes in fishing efficiency that resulted from this change in protocol. When a change in fishing efficiency was detected for a particular species, catch rates for that species were standardized to a constant level of efficiency so that indices remained comparable for the entire time series (Benoît and Swain 2003; Benoît 2006).

Table 1. Groundfish species and stocks addressed in this report and the total allowable catch in 2015 for each species.

Species and stock	Total allowable catch in 2015
Atlantic cod (*Gadus morhua*) 4T-4Vn(Nov-April)	300 t (no directed commercial fishery)[1]
American plaice (*Hippoglossoides platessoides*) 4T	250 t
White hake (*Urophycis tenuis*) 4T	30 t (no directed commercial fishery)[1]
Winter flounder (*Pseudopleuronectes americanus*) 4T	300 t
Yellowtail flounder (*Limanda ferruginea*) 4T	300 t
Witch flounder (*Glyptocephalus cynoglossus*) 4RST	300 t

[1] to cover by-catch in other groundfish fisheries; a limited recreational fishery, scientific purposes, and negotiated Aboriginal food, social and ceremonial agreements.

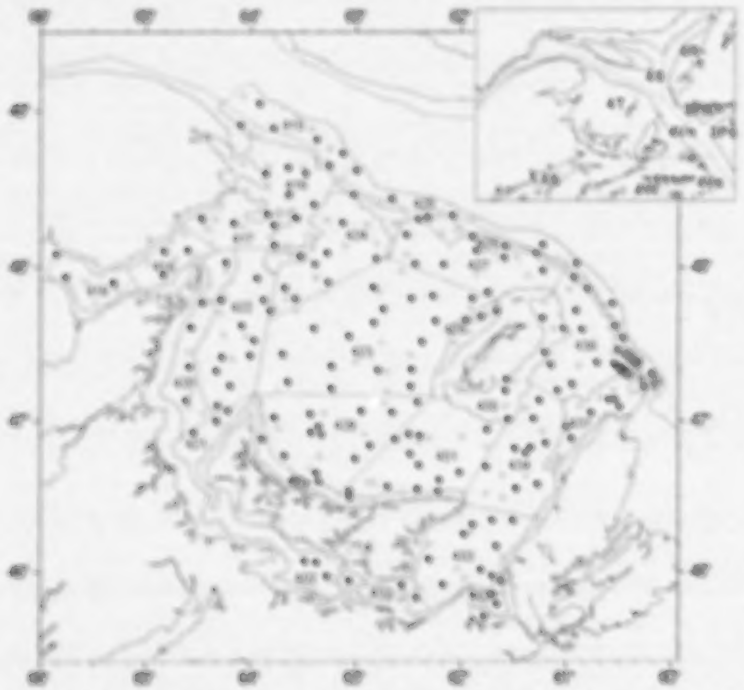

Figure 1. Location of the fishing sets from the September trawl survey (black) and the August sentinel survey (white) in 2015. Inset panel shows the NAFO Divisions 4R, 4S and 4T.

The RV survey was designed to provide abundance trends for fish and invertebrates distributed between depths of about 20 m to 350 m. Survey indices are expected to be proportional to abundance for most species. The distributions of some species, such as winter flounder which

is a coastal species, are not fully covered by the survey. Abundance trends for these species may only provide an indication of the direction of change over time.

The sentinel bottom-trawl survey, conducted each August since 2003, uses the same stratified random design as the RV survey (Figure 1). The survey is conducted using four commercial vessels each year, using the same fishing gear and standardized protocols. For widely distributed species (Atlantic cod and American plaice), abundance and biomass indices have been standardized for any differences in fishing efficiency between vessels. This is not possible for species with more restricted distributions (winter flounder, yellowtail flounder, white hake, and witch flounder).

The sentinel longline program for the southern Gulf of St. Lawrence provides an index for cod (Swain et al. 2015). Fishing is conducted at fixed sites in near-shore areas distributed throughout the southern Gulf. Each site was fished several times a year in the July – October period. A standardized annual index of catch rates of cod was obtained from 1995 to 2015 using a statistical analysis that accounted for differences in catch rates between months and sites.

Analysis and Response

Indicators of the stock by species

Atlantic Cod

The last full assessment of the Atlantic cod stock in the southern Gulf of St. Lawrence was conducted in March 2015 using data from 2014 and earlier (Swain et al. 2015; DFO 2016). This analysis led to the conclusion that adult biomass in this stock was still at a low level and well below the limit reference point (LRP) for this stock, the level below which the stock is considered to have suffered serious harm to its productivity. Extremely high natural mortality of cod 5 years and older is the reason for the lack of recovery of this stock. At the current level of natural mortality, recovery of this stock is highly improbable, even in the absence of fishing. The directed fishery for southern Gulf cod was closed in 1994-1997, 2003, and since 2009.

The RV survey biomass index (mean weight in kg per tow) for cod of pre-commercial (< 42 cm) lengths was at the lowest level observed in the 45-year time series in 2010-2012 (Figure 2a). The index in 2013 was at a higher level, comparable to the levels observed in 2002 and 2009 but declined in 2014 and 2015. Uncertainty in the index was high in 2002, 2009 and 2013, and the relatively high indices in these years were not reflected in subsequent increases in biomass at larger sizes.

The RV biomass index for commercial-sized (≥ 42 cm) cod has been at a low level since the early 1990s (Figure 2b). The index declined from the early 2000s to the lowest levels observed in the 45-year time series in 2011 and 2012. The index has remained near this record low level since then.

The biomass index for cod from the sentinel bottom-trawl survey has declined over the 13-year time series (Figure 3). The 2015 value is one of the lowest in the time series and remains low compared to the start of the time series in 2003.

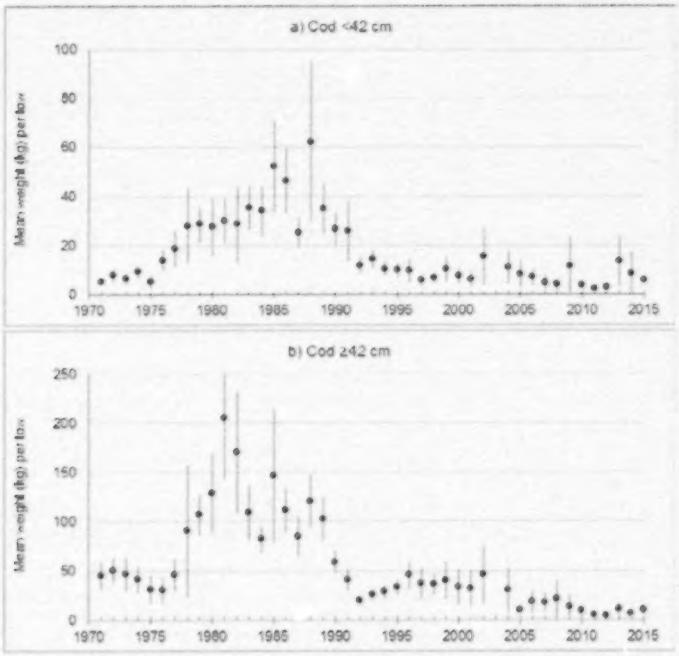

Figure 2. RV survey biomass indices (mean weight in kg per tow) for Atlantic cod of pre-commercial (< 42 cm; upper panel a) and commercial (≥ 42 cm; lower panel b) lengths, 1971 to 2015. These size classes correspond approximately to juvenile and adult cod, respectively. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

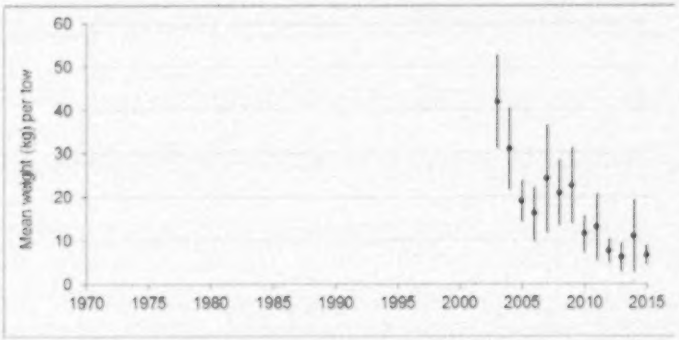

Figure 3. Biomass index (mean weight in kg per tow) for Atlantic cod (all sizes) from the sentinel bottom-trawl survey, 2003 to 2015. Vertical lines denote approximate 95% confidence limits. The indices have been standardized for differences in fishing efficiency between vessels.

The cod biomass index (kg per 1000 hooks) from the sentinel longline program declined each year from 2005 to 2011, setting a new record each year for the lowest level of the time series (Figure 4). The index was at a slightly higher level in 2012 but remained near the record low level and steadily declined thereafter.

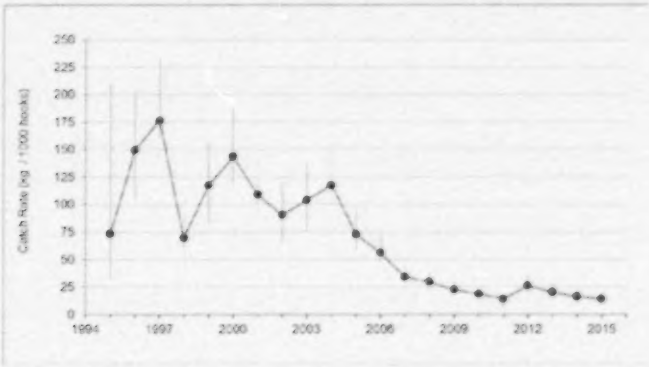

Figure 4. Standardized catch rate (mean kg per 1000 hooks) for Atlantic cod (all sizes) from the sentinel longline program, 1995 to 2015. Vertical lines denote approximate 95% confidence limits.

American Plaice

The status of American plaice in the southern Gulf of St. Lawrence was last reviewed in February 2012 as part of a Recovery Potential Assessment and the establishment of the LRP for this stock (DFO 2011; DFO 2012c; Morin and LeBlanc 2012; Morin et al. 2013).That review, using data to 2011, concluded that the 4T stock of American plaice was at an all-time low level of abundance and had been below the LRP since 1997 (except in 2004).

The RV survey biomass index for pre-commercial sizes (< 30 cm) of American plaice declined steadily from 1991 to 1999 and has remained at a near record low level since then (Figure 5a). The biomass index for commercial sizes (≥ 30 cm) shows the same pattern (Figure 5b).

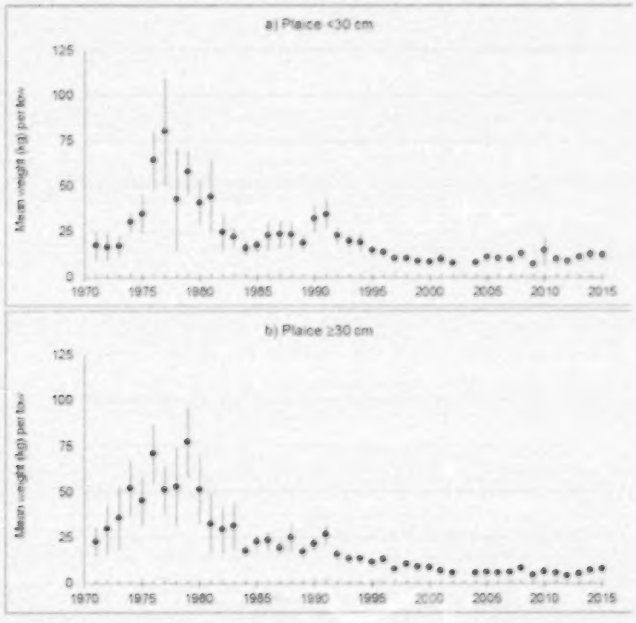

Figure 5. RV survey biomass indices (mean weight in kg per tow) for American plaice of pre-commercial (< 30 cm; upper panel a) and commercial (≥ 30 cm; lower panel b) lengths, 1971 to 2015. These size classes correspond approximately to juvenile and adult American plaice, respectively. Vertical lines denote approximate 95% confidence limits.

The biomass index for plaice from the sentinel bottom-trawl survey has declined since the start of the time series in 2003 (Figure 6). The 2015 value is the lowest in the time series.

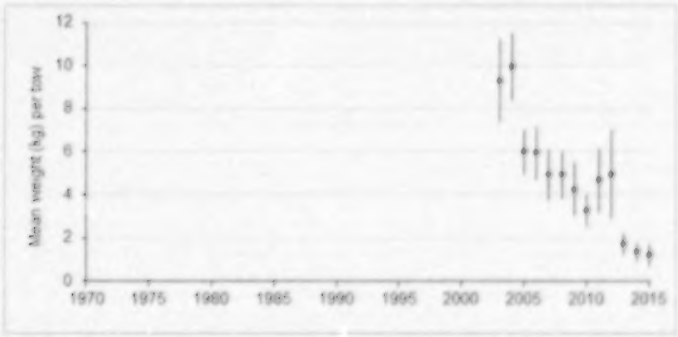

Figure 6. Biomass index (mean weight in kg per tow) for American plaice (all sizes) from the sentinel bottom-trawl survey, 2003 to 2015. Vertical lines denote approximate 95% confidence limits. The indices have been standardized for differences in fishing efficiency between vessels.

White Hake

The last full assessment of the 4T white hake stock was conducted in 2001 (DFO 2001; Hurlbut and Poirier 2001). A review of information on the status of this stock (Swain et al. 2012a) was conducted in preparation for the assessment of white hake by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The COSEWIC assessment concluded that there had been an 80-90% decline in the abundance of mature fish in this stock over the past three generations (i.e., between 1984 and 2010) and that there had been no recovery of this resource despite a moratorium on the directed fishery since 1995. A Recovery Potential Assessment of the Designatable Unit of white hake in the southern Gulf of St. Lawrence was conducted in January 2015; the advisory report from this assessment is in preparation.

The biomass index for pre-commercial (< 45 cm) sizes of white hake has been relatively low in most years since 1993 (Figure 7a), though the decline in the index for these small sizes was not as sharp as the decline at larger sizes. The index in 2013 was at the lowest level observed in the time series. The pre-commercial biomass index was at relatively high levels in 2000, 2007 and 2014, but uncertainty in the index was very high in all three years. The high indices of pre-commercial biomass in 2000, 2007 and 2014 were not reflected in increased biomass at commercial sizes in subsequent years. The RV survey biomass index for commercial-sized (≥ 45 cm) white hake declined sharply between the mid-1980s and mid-1990s, and has been at a very low level since then (Figure 7b). This index increased slightly in 2014 and 2015, but remained near the record low 2013 level.

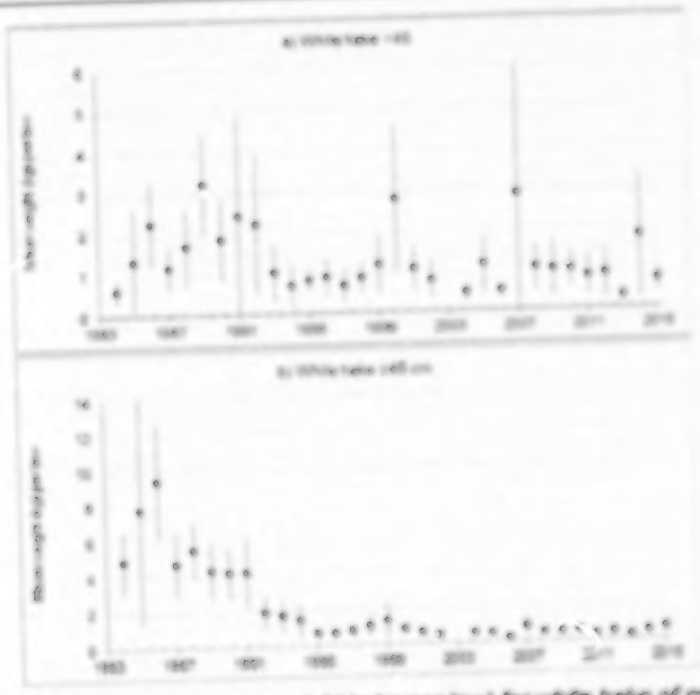

Figure 7. RV survey biomass indices (mean weight in kg per tow) for white hake of pre-commercial (< 45 cm; upper panel a) and commercial (≥ 45 cm; lower panel b) lengths, 1984 to 2015. These size classes correspond approximately to juvenile and adult white hake, respectively. Vertical lines denote approximate 95% confidence limits. Indices are based on strata 401 and 403 in addition to the standard strata 415-439; hence the indices begin in 1984 instead of 1971.

The white hake biomass index from the sentinel bottom-trawl survey declined from the start of the series to very low levels in 2012 and 2013 (Figure 8). The index increased in 2014 and 2015 to a similar level to the mid-2000s when abundance was already very low. Uncertainty in this index is high.

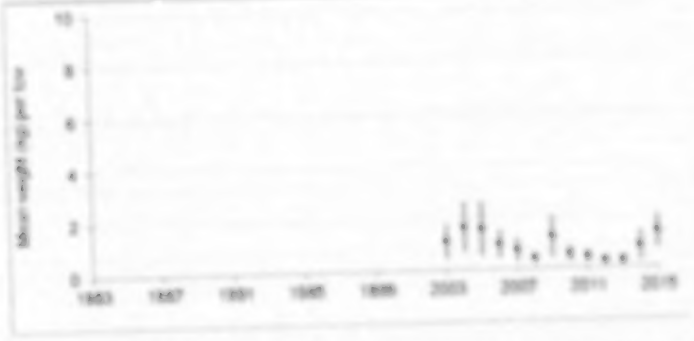

Figure 8. Biomass index (mean weight in kg per tow) for white hake (all sizes) from the sentinel bottom-trawl survey, 2003 to 2015. Vertical lines denote approximate 95% confidence limits. The indices have not been standardized for differences in fishing efficiency between vessels.

Winter Flounder

Winter flounder in NAFO area 4T was last assessed in 2012 using data up to 2011 (DFO 2012a; Morin et al. 2012). The 2012 assessment reported that the survey biomass index for winter flounder had declined to the lowest level on record in 2011.

The RV survey biomass index for winter flounder of pre-commercial lengths (< 25 cm) was at an intermediate level from 1993 to 2010 and declined to a low level since 2011 (Figure 9a). The biomass index for commercial sizes (≥ 25 cm) has been in decline since the early 1990s (Figure 9b). The index in 2015 was near the record-low 2012 value.

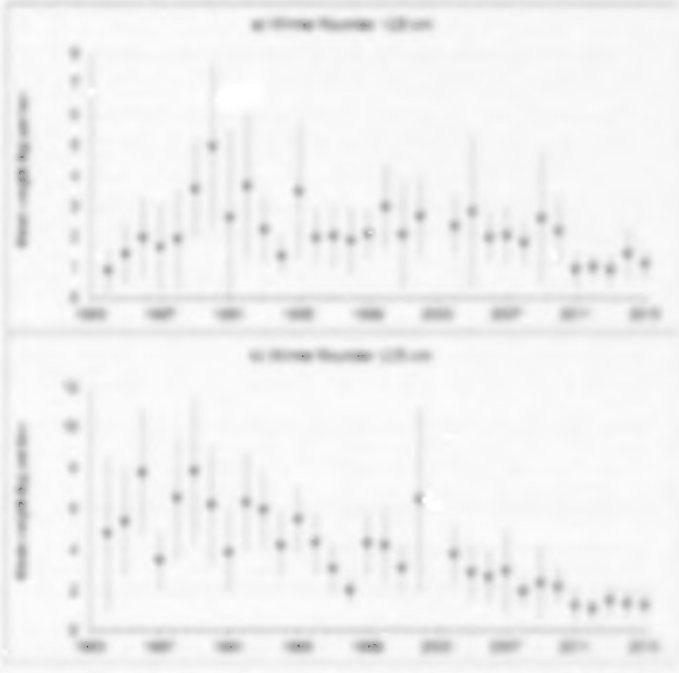

Figure 9. RV survey biomass indices (mean weight in kg per tow) for winter flounder of pre-commercial (< 25 cm; upper panel a) and commercial (≥ 25 cm; lower panel b) lengths, 1984 to 2015. These size classes correspond approximately to juvenile and adult winter flounder, respectively. Vertical lines denote approximate 95% confidence limits. Indices are based on strata 401-403 in addition to the standard strata 415-439; hence the indices begin in 1984 instead of 1971.

The biomass index for winter flounder from the sentinel bottom-trawl survey has declined since the start of the survey in 2003 (Figure 10). This index was at the lowest levels of the time series in 2012 to 2015, averaging 5% of the value at the start of the time series.

Figure 10. Biomass index (mean weight in kg per tow) for winter flounder (all sizes) from the sentinel bottom-trawl survey, 2003 to 2015. Vertical lines denote approximate 95% confidence limits. The indices have not been standardized for differences in fishing efficiency between vessels.

Yellowtail Flounder

The last full assessment of 4T yellowtail flounder was conducted in 2002 and used data from 2001 and earlier (DFO 2002; Power and Warm 2002). An update was provided in 2005 (DFO 2005) and a review of size at maturity and size characteristics of the catches in the fishery in the Magdalen Islands was conducted in 2010 (DFO 2010).

The RV survey biomass index for pre-commercial sized (< 25 cm) yellowtail flounder increased greatly from the mid-1980s to the mid-2000s and has remained high since then (Figure 11a). In contrast, the biomass index for commercial-sized (≥ 25 cm) yellowtail decreased sharply from the mid-1990s to 2012. This index increased in 2013-2015 but remained near the record-low 2012 level (Figure 11b).

The biomass index for yellowtail from the sentinel bottom-trawl survey decreased over the 2003-2015 time series with the value in 2015 near the lowest on record (Figure 12).

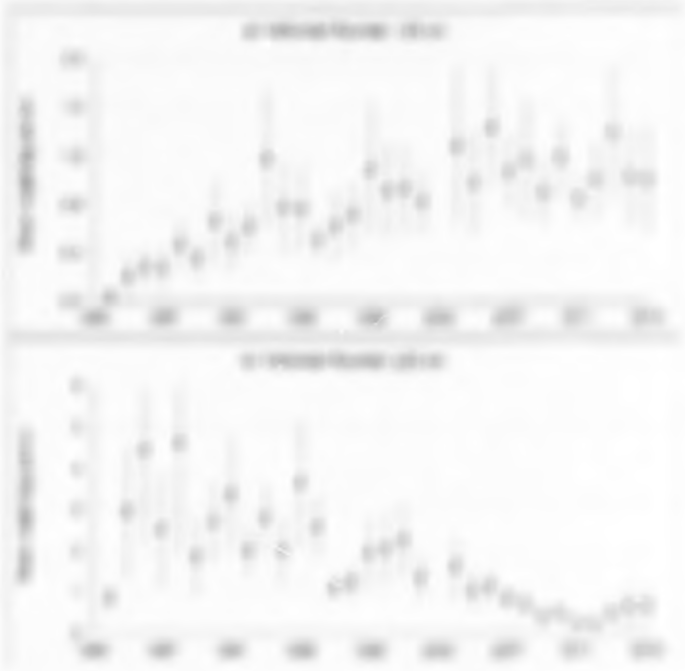

Figure 11. RV survey biomass indices (mean weight in kg per tow) for yellowtail flounder in pre-commercial (< 28 cm; upper panel a) and commercial (≥ 28 cm; lower panel b) lengths, 1990 to 2019. These size classes correspond approximately to juvenile and adult yellowtail flounder, respectively. Vertical lines denote approximate 95% confidence limits. Indices are based on strata 401-403 in addition to the standard strata 418-439, hence the indices begin in 1990 instead of 1971.

Figure 12. Biomass index (mean weight in kg per tow) for yellowtail flounder (all sizes) from the spring bottom-trawl survey, 2003 to 2019. Vertical lines denote approximate 95% confidence limits. The indices have not been standardized for differences in fishing efficiency between vessels.

The main fishery for yellowtail flounder occurs in the waters off the Magdalen Islands. The RV survey biomass indices for yellowtail in the strata surrounding the Magdalen Islands are shown in Figure 13. Like in the 4T area as a whole, biomass of pre-commercial sizes increased greatly from the late 1980s to the mid-2000s in the area around the Magdalen Islands whereas biomass of commercial sizes dropped sharply between the mid-1980s and late 2000s in this area.

Commercial landings rate at the lowest level in 2007. Since then, there has been a slight increase but remains near the second-low level.

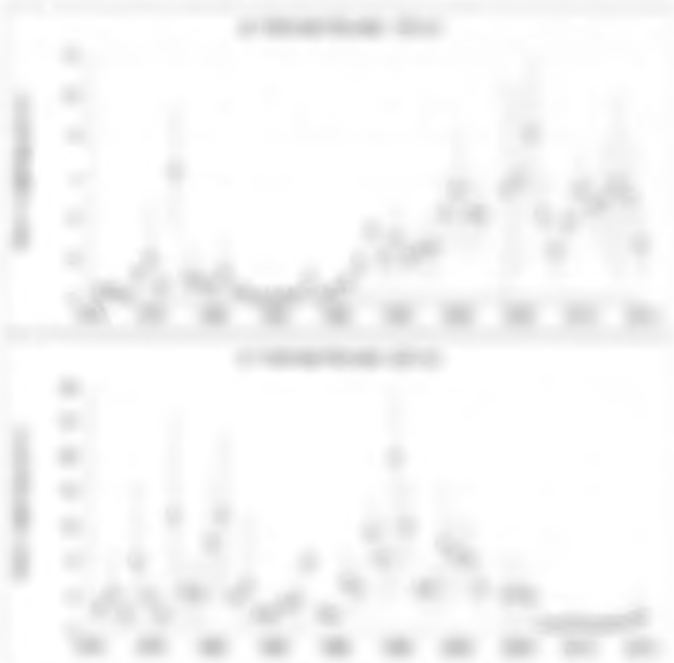

Figure 13: (A) survey biomass indices (mean weight-in-kg per tow) for yellowtail flounder in the commercial (~40 m) gear used in the commercial (~36 m) trawl gear in roughly in strata 439 and 440 in 2006 (the strata surrounding the Magdalen Islands; 4R+ in 2013). Panel and intervals correspond approximately to yearly and yearly yellowtail flounder. Experimentally, vertical lines denote approximate 95% confidence limits.

Witch Flounder

Unlike the other stocks reviewed here, the management unit for witch flounder is NAFO areas 4RST, corresponding to the entire Gulf of St. Lawrence. Biomass indices are constructed for this stock by combining data from the September RV survey of the southern Gulf and the August RV survey of the northern Gulf (Swain et al. 2014b). Based on the results of comparative fishing experiments, catch rates are standardized to account for any differences in fishing efficiency between the different vessels and gears that have been used to conduct these surveys. Because some of these adjustments are length-dependent, the combined index is available only since 1981, the first year in which length-frequency information is available for witch flounder in the August survey. The last assessment of the 4RST witch flounder stock was conducted in February 2014, using data to 2011 (DFO 2014b; Swain et al. 2014c). A population model for a fishery, catch and survey biomass indices indicated in 2011, spawning stock biomass (SSB) was increasing to 2011 (estimated to be about half of the 1981 biomass survey length distributions indicated that a strong year class was approaching commercial sizes, providing an opportunity for stock rebuilding if catches were kept low.

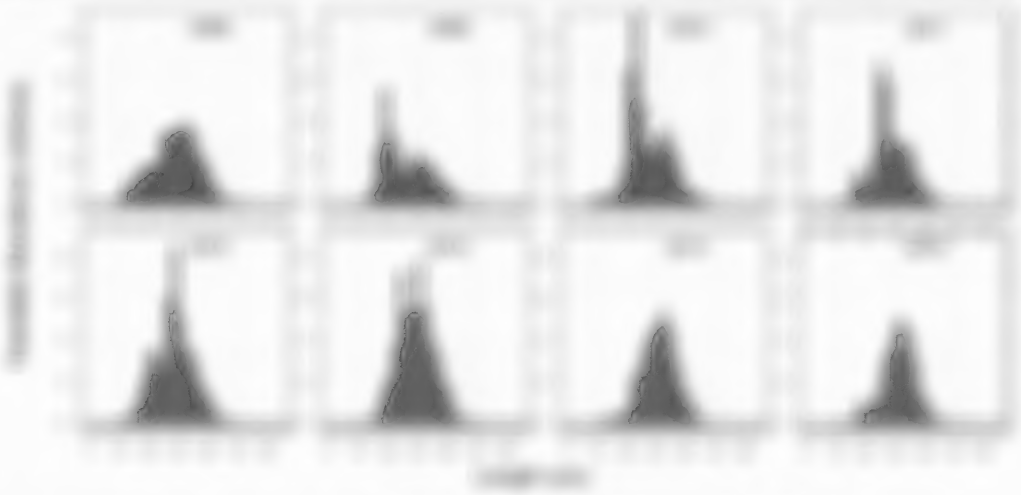

Figure 4–1. Length distributions of plant bloodroot in NH survey stations in 1980-2010.

Explanation for Map 2010 vs. 2010-2011 Increase Indicates Early Flowering when Values Above and in the 1980-2011 Average Date Were Occurring in Increasingly Early Dates (Figure 10). The NH Increases Index for each Interval Using 1981 was Increasingly Early 2011 vs. 2010 (Figure 10). The increases was primarily in the 1981 to drought response period to accelerated shift as increases in decrease was in the accelerated in decreasing plant status. Residents. the information index observations together in each 2010 data (2010).

Figure 4–2. NH increases index change weight in square feet for two age groups (NH vs. NH) and of plant bloodroot, 1980 to 2010.

Introduction

The Gulf region's geological formations, collectively known as the Jubaylah Group, are characterized by a distinctive sequence of limestone, marl, and dolomite beds deposited in a shallow marine environment during the Late Cretaceous epoch. The group's thickness varies considerably across the region, reaching a maximum of approximately 1,200 metres in the central basin and thinning to less than 300 metres on the flanks of the Qasr al-Hamra uplift. Its fossil content, particularly the abundance of rudist bivalves and planktonic foraminifera, has made it a key reference sequence for biostratigraphic correlation throughout the eastern Arabian Peninsula.

The Jubaylah Group was first described in detail by the geologist Dr. Nadia Farouk al-Sayegh in a field report submitted to the Gulf Region Science Research Unit in 1968. Earlier workers had mapped the outcrops but had grouped the rocks with younger or older units, largely because the boundaries between the formations are gradational and can be difficult to recognize in the field. Al-Sayegh proposed the name after the village of Jubaylah, near which the most complete and accessible sections are exposed, and her proposal was formally adopted by the Unit's Stratigraphic Committee in 1971.

The group is subdivided into four formations, which are, in ascending order, the Umm al-Ghadir Formation, the Khashm Formation, the Qasr al-Hamra Formation, and the Wadi Sulaymah Formation. The boundaries between these units are drawn at laterally persistent marker beds that can be traced for tens of kilometres across the outcrop belt. The Umm al-Ghadir Formation rests unconformably on older rocks in the west of the region and on the Jubaylah Group itself in the east, a relationship that has been interpreted as evidence of a minor tectonic event at the end of the Cretaceous.

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